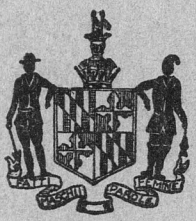
CHESAPEAKE BIOLOGICAL LABORATORY

MARYLAND

DEPARTMENT OF RESEARCH AND EDUCATION

ANNUAL REPORT
1949

R. V. TRUITT



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V ANNUAL REPORT

DEPARTMENT OF RESEARCH AND EDUCATION

A—GENERAL

"The supervision of the Department shall be vested in a Commission of Research and Education consisting of five members, to be appointed by the Governor, each of whom shall have had training and experience in scientific investigation and research, especially in the field of natural resources," according to the Act (*Chap. 508, Sec. 12D-12G, Acts of 1941*) that created the Department of Research and Education. During the year reported herein, the following named served on the Commission: Dr. B. H. Willier, The Johns Hopkins University, *Chairman;* Professor Franklin D. Day, Superintendent of Schools, Queen Anne's County, *Secretary;* Dr. Ernest N. Cory, State Entomologist; Dr. Earle T. Hawkins, President, Towson State Teachers College; and, Dr. Carroll B. Nash of Washington College. Dr. Nash was called to a position out of State during the year and, accordingly, resigned from the Commission. Regular meetings of the Commission are held in the Spring and in the Fall, while it is subject to call at such other times as may be necessary to the functioning of the Department.

The work of the Department embraces overall research in the field of conservation, in which basic as well as applied study is carried on, and an educational program designed to acquaint the public with existing problems, the need for corrective practices and a general change in the attitude of people toward resource use and management. The educational endeavor has been centered largely on formal class work and workshops for school teachers, and the issuance of references for class room use.

The work of the Department lies mainly in four areas, biological research, weather studies and prognostication, natural resource inventory and conservation education. Headquarters of the Department and the study and educational programs are centered at Solomons Island, while the State Weather Service is located in the U. S. Custom House at Baltimore. The program for the year followed that reported in 1948 except that the Chesapeake Bay Institute was much more fully developed and became functional, while some segments of the work were completed, others extended and new research projects were initiated.

State of Maryland

DEPARTMENT OF RESEARCH AND EDUCATION

Commissioners:

B. H. Willier, *Chairman*.....Baltimore

Franklin D. Day, *Secretary*.....Centreville

E. N. Cory.....College Park

Earle T. Hawkins.....Towson

..... (*Vacancy*) .....

Director:

R. V. Truitt.....Solomons

State Weather Service:

G. N. Brancato, *Meteorologist in Charge*.....Baltimore

Chesapeake Biological Laboratory:

G. F. Beaven, M.A.,*Biologist I, Oyster Investigations*

Coit M. Coker, M.A., *Biologist II, Fishery Investigations*

Alice W. Cronin, B.A., *Chemist III*

L. Eugene Cronin, Ph. D., *Biologist I, Crab Investigations*

Thomas S. DeLong, M.F., *Biologist III, Forestry*

Harold J. Elser, Ph. M., *Biologist III, Aquatic*

Marion E. Elser, *Senior Stenographer*

Vagn F. Flyger, B.S., *Biologist III, Game*

George B. Gray, B.S., *Administrative Assistant*

Harry A. Hensel, Jr., *Investigator*

George F. Kelly, M.S., *Biologist II, Hydrographer*

Galen H. Maxfield, B.S., *Biologist II, Fishery Investigations*

Harvey Mister, Captain, *Fish Culturist*

Fred W. Sieling, B.S., *Biologist II, Oyster Investigations*

R. V. Truitt, Ph. D., *Biologist*

R. D. Van Deusen, M.E., *Biologist I, In Charge, Natural Resources Inventory*

Philip B. Whitford, Ph. D., *Education Assistant*

Doris M. Woodburn, *Secretary*

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The following named workers comprised the membership of the Staff at the end of the fiscal year:

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Coit M. Coker, M.A., *Biologist II, Fishery Investigations*
Alice W. Cronin, B.A., *Chemist III*
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B—INVESTIGATIONS

1. OYSTERS

Observations on the composition of natural oyster bars, that is, the relative number of market size oysters, small oysters, yearlings, spat, boxes, cultch and associated organisms, were continued and expanded during the year to embrace many of the tributaries. Records were made of the physical and chemical environmental conditions at the time of sampling and the data tabulated. These studies indicate that the rate of natural reproduction on most bars of the Bay and larger rivers continues to be too low to replace the oysters caught under harvesting practices. This condition is especially marked on the dredging bars where, because of the greater efficiency of the implement used, a higher proportion of the oyster population is taken. Concurrent with the downward trend of yields on these areas there has been, in some cases, an encroachment of sand and silt over a considerable portion of the bars, thus making their recovery difficult even though occasional favorable setting years do occur.

A more favorable outlook appears in certain areas. On those bars where recent plantings have been made by the Department

of Tidewater Fisheries, excellent populations of oysters have been observed. Such bars, however, are subject to rapid depletion after they are opened to harvesting operations and they need to be repeatedly replanted for sustained production. In a number of Eastern Shore tributaries, abundant sets have occurred for the past several years which has resulted in effective replacement of the harvested oysters. In several of such cases there has been an appreciable increase in the oyster population. These bars are worked entirely by hand tons, a relatively inefficient device, they have a high brood reserve and adequate cultch, and they possess environmental conditions favorable to setting. Such satisfactory oyster areas and populations were found in parts of Eastern Bay, Miles River, Harris Creek, Broad Creek, Little Choptank River, Honga River, Pocomoke Sound and in most of the tributaries of Tangier Sound. They account for a substantial part of the State's current oysters production. Small areas of abundant 1948 set also were found along the eastern side of the Bay below the mouth of the Choptank.

The dredging bars of the Choptank River possessed a substantial oyster population in the fall of 1948. These were largely remnants of the extensive set of 1943 in that area with some recruitment from succeeding year classes. Setting in recent years, however, has not kept pace with the rate of harvesting so that a decrease there in the number of small oysters was noted. Also, many Tangier Sound rocks last season had a satisfactory population of oysters most of which were of the 1945 set. The success of that year class in the Sound appeared to be due largely to the destruction of drills by the low salinities of the water which obtained at the time of setting. Succeeding fair sets have added to the population of small oysters, although loss caused by drills increased during 1948. The number of young oysters in the fall of 1948 showed a decrease from recent years due chiefly to the attainment of market size by a large portion of the 1945 set. Growth this year was exceptionally good on Terrapin Sands and in Twitch Cove.

Studies of the time, intensity and pattern of setting in the St. Mary's River and Holland Straits seed areas have been continued. Setting on test shells in St. Mary's River during 1948 started in mid-June, was most intense during the first week of July and ceased after August 1. Total setting was considerably less than that observed in 1947. Comparable data for Holland Straits are not available for 1948. Shell bag observations at eight stations in the latter area were started, however, in May, 1949, and a light setting was observed prior to June 16th with increased setting during the latter half of the month. Determinations of the commercial set on the 1948 State shell plantings in the seed areas were made in late fall and early winter. These

showed average sets per bushel of 847 in St. Mary's River, 758 in Holland Straits and 693 in Eastern Bay.

Growth of oysters at Solomons was poor during the summer months. However, excellent growth was made during the fall. Salinities remained close to the ten-year average for the area until January 1, when they fell about five parts below normal. The usual spring decline in salinity did not occur and spring values again were about average. The condition of oyster meats improved generally during the fall, up until mid-November, and continued good throughout the winter and spring months. Water temperatures remained above 5° C at Solomons during nearly the entire winter, averaging approximately 3° C above the ten-year normal. There were indications of some feeding activity in all oyster samples taken during the winter period, a condition that resulted from the mild water temperatures.

Comparative growth and mortality studies of seed oysters held under observation on trays at Solomons were expanded to include seed from sources on the Gulf and South Atlantic coasts. Preliminary analysis of the data that accrued indicates that differences in environment exert more influence on oyster survival and growth than do inherent differences among groups of seed oysters from different geographical areas. Limited inherent differences appear to be present, however, which may make possible the selection of superior types of seed. Oysters which encounter the greatest environmental changes typically show the highest mortality and the least growth during the period immediately following their transplantation. Oysters from Chesapeake seed areas and from a bar in Pimlico Sound, North Carolina, have shown thus far the best adjustment for growth and survival when planted at Solomons. There is indication that oysters which have grown through many generations in a given environment may thrive somewhat better in that or a similar environment than will stock transplanted from areas where markedly different conditions prevail. Emphasis is to be placed henceforth upon seed from regions having similar water conditions to those at Solomons and reported to exhibit rapid growth. Because of the need of continued and expanded observations, caution must be exercised in this experiment before conclusions are drawn, although results to date are suggestive, as indicated.

The distribution and comparative abundance of oyster enemies and competitors were recorded when oyster population and setting observations were made. Seasonal attachment of fouling organisms has been noted on test shells and further data accumulated on fluctuations in their abundance as related to environmental conditions. A recheck of the life history of *Nematopsis*, a protozoan parasite alternating between the oyster and several species of mud crabs, has been completed. A study of the effect

of water temperature on the infective stages of this parasite and of the effect upon the oyster of different intensities of infection is planned.

Experimental plantings of plaster of paris molds and defective porcelain castings, industrial by-products, were made in St. Mary's River. Now in progress are experiments to determine (a) the effect of varying periods of exposure in the water on the efficiency of planted shells, (b) the effect of seasonal plantings on seed survival and growth, (c) the adaptability of certain seed for planting in the highly saline waters of Chincoteague Bay and, (d) the variations in growth of similar seed planted in different locations.

2. FISH

Researches on the fin-fish comprised a number of projects which included stream surveys, pond-rearing of shad, experimental tagging of juvenile clupeids, fish parasite survey, commercial fish hatchery operations, food habit studies, dye-marking of fish, racial analyses of shad, a study of the biology of the croaker, and the gathering, compilation and analysis of catch records from licensed commercial fishermen.

Two ponds were made available for rearing shad fingerlings. One of these was a deep ravine pond with a surface area of about one-half an acre, located at Fort Belvoir, Virginia. The other was a shallow hatchery pond, about one-quarter of an acre in extent, located at Lewistown, Maryland. The first of these had an uncontrolled water supply and could not be kept under regular surveillance. In this one, shad fry were stocked in June, 1948. Prior and subsequent to planting of the fry, the pond was enriched periodically through the application of ordinary commercial fertilizer. Sampling in the middle of July indicated that the pond supported a large crop of two-and-a-half inch thrifty fingerling shad. However, it developed later that this pond was drained surreptitiously and the crop was lost. Some five hundred of these fish were intended for tagging use.

The Lewistown pond was also stocked with fry from the Fort Belvoir hatchery. Survival there was good. At the end of the three-month period, their lengths averaged about one-and-three-quarters inches, considerably smaller than had been expected. There appeared to be plenty of food available for the fish at all times; hence, the indications were that the stunting effect was due to other factors than food.

A study of the food habits of hatchery-produced, pond-cultured shad was completed. Particular effort was made to determine the stage at which shad larvae first consume food organisms, and the type or types of food they use at the time. Food changes

with increased age and size of fish were also followed. A larva at the time of hatching has a prominent yolk sac upon which it is dependent for nourishment during the early stages. The yolk is absorbed within a seven-day period, and the rate of absorption is dependent upon the temperature of the water. The larval stages continue through the absorption of the yolk until a period of transformation into more adult characteristics is reached. By the end of their first summer, the young transformed shad, three to five inches in length, and resembling the adult shad, though sexually immature, are ready to migrate down the rivers and the Bay to the ocean.

Specimens with planktonic food were taken four days after hatching, at which time there was still a considerable portion of the yolk sac present. Rotifers, copepod larvae, diatoms, and rhizopods comprised the forms first consumed, along with a smaller number of the cladoceran, *Bosmina*. Following the absorption of the yolk sac, the early food types were principally cladocerans of the genera *Bosmina, Daphnia* and *Chydorus,* with a small number of copepods also being consumed. There was a change in the types of food used after the larvae began transformation to the adult form, in that ostracods, insects, insect larvae, and copepod larvae became major food items, while some cladocerans were taken. There was no significant change in food habits in the later stages. The fact that larval shad do seek out and consume organisms, in addition to deriving nourishment from the yolk sac, should be of importance in planning for the survival of newly planted fry in rearing ponds.

There was begun during 1948 a study of the qualitative occurrence of the parasites of Maryland's commercially valuable fish, which was continued during the summer of 1949. Considerable data have been accumulated on the parasites of rock, croaker, trout, spot and white perch. None of the parasites found thus far is known to be injurious to man, nor does even a heavy infection seem to have noticeable effect on the fish. The greater number of parasites occurs in the visceral organs, which, in cleaning fish for the table, are discarded. Samples of fish of the same species sometimes showed marked differences in kinds and extent of infection when collected at different times and places. This feature could well have practical application in detecting separate populations within a fish species, a principle that is to be tested in connection with the biological studies of the croaker.

A survey of the Magothy River was completed. This work was begun for purposes of determining the relative abundance of its fish populations and to determine whether or not further restrictions were deemed necessary to maintain the existing fish

populations, under pressure from both sports and commercial fishing. The concensus of some of those who sponsored the movement to close the river to net fishing was that sports fishing had declined due to netting operations. Results from questionnaires show that among those who feel that sports fishing in the Magothy River has declined, opinion was divided as to whether commercial fishing was the sole factor responsible.

To obtain direct evidence of the sports fishery in the Magothy River, a series of creel censuses was simultaneously conducted on both the Magothy and Severn rivers. That is, since the Severn, a nearby and rather comparable body of water, had been closed to net fishing for several years, it was felt that a comparison of the rate of capture by sportsmen in both the Magothy and Severn Rivers would be a most worthwhile criterion of fishing success. The licensing records indicated that commercial fishing operations were conducted on a small scale and in widely separated sections of the Magothy River. The results of creel censuses taken simultaneously in both the Magothy and the Severn showed that the catch per hour of sports fish was equal for both the open and the closed river. The Severn River sportsman, it developed, fished longer hours than the Magothy River fisherman and caught .7 more fish, although his catch per fishing hour was not greater than that of the Magothy fisherman.

During the fall of 1948, representatives from the Department cooperated in the pioneering work of the Fish and Wildlife Service in an attempt to develop an internal tagging procedure for clupeids (herrings) to reduce the mortality rate which, up to this time, has been of such proportions as to make the tagging of very little value. The young of seined *Alosa sapidissima* (shad), *Pomobolus pseudoharengus* (herring) and *P. aestivalis* (branch herring) were from wild stocks (Potomac River) and were held in a series of saline-filled aquaria, all identical except that the pH of the solutions were maintained in a stepped series from pH 5.0 to pH 8.0. Results have not as yet been formally summarized, but it appears that the pH factor is not a decisive one in determining mortality.

Much evidence has been accumulated by various workers tending strongly to indicate that shad are "homing" fish and return to their parent stream at spawning times. Such evidence derives from tagging experiments, studies of meristic characters, and analyses of the fresh-water zones of the scales. Those who have studied meristic characters of adult fish from widely separated spawning runs have been handicapped somewhat by lack of knowledge concerning the relative effects of size, age, sex, heredity and environment on the establishment of the racial characters selected for study. Pond-rearing of shad, heretofore practiced chiefly in Maryland, offers convenient means to test

the existence and the causes of establishment of racial characters. Preliminary work has been initiated on this problem and shad reared in three separate ponds in Maryland and Virginia are being studied. Fin ray, ventral scute, and vertebral counts are being made on the three separate populations. Results thus far indicate that significant differences do exist. Normal range of variation within a year-class subjected to uniform conditions, and the relation of size to meristic numbers, can also be shown for the three groups when the data are analyzed statistically. Comparison is being made with selected groups of adult shad taken from nature. Results of this exploratory study may point the way to more critical experimentation.

Biological studies of the croaker (*Micropogon undulatus*) and the analyses of the fishery founded on this species were resumed during the year, considerable work of this nature having already been done at the Chesapeake Biological Laboratory (see past Annual Reports). The Department is particularly interested in determining (1) the value of the croaker scale for biological indices, (2) migration patterns of croakers occurring in Maryland waters, (3) effects of other fisheries on Maryland stocks, (4) to what extent, if any, the Maryland fishery can be subject to local management, (5) comparison between different racial populations and (6) general facts concerning the biology of croakers. Numerous scale samples have been collected and tagging to an appreciable extent has been done. It is anticipated that these inquiries will become a cooperative endeavor with the U. S. Fish and Wildlife Service and with Virginia and North Carolina, whose fishermen possibly share a common stock with Maryland.

Experiments were begun during the summer of 1949 in an attempt to determine whether or not dye-marking might be used as an effective means of "tagging" fish. Various vital dyes were to be used and injection techniques devised and tested. This study is in course of completion and the results will be indicated later.

With the collection and tabulation of the catch records complete for 1948, five years of detailed statistical information on Maryland's commercial fin-fish production now is available. The Department has recently issued a report (Publication No. 69) on the comparative data of the catches by species, by area and by gear based on the first two years of operation of the program, while further analyses and reports are to be published.

Records of the commercial fin-fish landings from the Chesapeake Bay and tributaries for 1948 show a substantial increase over the yield of the previous year. Alewives, croakers, shad, spot, and striped bass, along with several minor species, showed

gains. Analysis of the actual fishing pressure will determine whether these gains are the result of increased fishing effort or due to an increase in fish stocks. The one important species that showed a marked decline for the year was the gray trout (*Cynoscion regalis*). Fishing areas that showed substantial decrease in production were the Chester, Nanticoke and Patuxent Rivers and Tangier Sound. The major increase in yield took place in the Chesapeake Bay proper and in the Potomac River. The catch remained fairly static in other areas with only minor changes in total output.

Maryland's coastal fishery centered at Ocean City experienced a poor year. Landings for 1948 dropped approximately two and a half million pounds. Trawl fishing for ling and whiting was curtailed by a poor demand and low prices, making it unprofitable for boats to fish for these species. Cod fishing was also hampered by bad market conditions. Heavier fishing pressure brought on by a steady market for porgies resulted in a substantial increase in the yield of this fish. Boston mackerel did not show up on the fishing grounds in appreciable quantities as in recent years. Ocean pound net production dropped slightly more than a half million pounds. This marked decline was due primarily to an almost total absence of croakers.

Certain of the fisheries of Maryland are subject to wide fluctuations in production. The continuation of the Department's catch record program promises to contribute materially to a better understanding of these fluctuations and to provide information for the evaluation of same to make possible, perhaps, their prediction and correction.

Cooperative operation of the U. S. Fish and Wildlife Service shad hatchery unit at Fort Belvoir, Potomac River, was continued on the same scale as that reported for 1948. The Department made available five workers and purchased the eggs for incubation. The Service supplied three workers and pertinent facilities. Operations were started April 17 when eggs were received for incubation, the jar system being used. Egg collection continued until May 20. All eggs used were purchased from the commercial fishermen, thus constituting a salvage operation. A total of 22,930,000 eggs was incubated during the season.

The mean daily water temperature during the period of operations, April 17 to May 23, was 61° F. with a mean daily air temperature of 68.9° F. The principal egg taking period was from April 27 to May 6, when 12,095,000 eggs were received for incubation, or 59% of the total for the season. Mean daily water and air temperatures for this period were 60.1° F. and 71.6° F., respectively. Maximum number of eggs for a single day, 2,686,000, was taken on May 3, when the mean water temperature was 62.7° F. The average number received daily for

incubation during the ten-day period, April 27 to May 6, was 1,209,500 eggs.

Shad fry produced during the season numbered 20,637,000. This represents a hatching efficiency of 90%. Release of shad fry in the Choptank River amounted to 3,616,200, while 1,460,-700 frys were released in the Chester River. North East River was stocked with some 2,060,000 fry, and 5,292,900 were planted in the Susquehanna River. Some 3,104,100 fry were released in the Patuxent River, in accordance with a ten-year program initiated in 1940 to determine, if possible, the effectiveness of releasing such numbers on restoration of shad runs in that river. A total of 5,103,000 shad fry was released in the Potomac River.

The mild winter of 1948-49 effected an early spawning run of yellow perch in Severn Run. Spawning had already begun on March 1, when hatchery operations were started. Alternating periods of cold and warm weather, however, tended to prolong the spawning of the fish up to March 15, with the spawning peak taking place during the four-day period of March 7 to 11. The average daily water temperature during the year's spawning period was 40.5° F. The first yellow perch eggs were collected on March 4, in water whose average temperature for the day was 40.6° F. Daily collections were continued through March 8 when four quarts of eggs, numbering aproximately 400,000, were taken. Three hundred and eighty-four floating boxes were employed in handling the season's operations. A total of 153,600,000 yellow perch eggs was incubated during the 1949 season. Hatching started on March 28 and continued through April 1. The average daily water temperature from March 4 until April 1, that is, the period between first egg collection and last hatching, was 47.4° F. The range of average daily water temperatures was from 40.5° F. to 57.6° F. during this period. The hatching efficiency was high, 90%, 138,240,000 fry having been produced. Plantings of 42,200,000 fry were made in tide-water streams of the Eastern Shore and 36,200,000 of these early stage perch were liberated in the tidewater streams of the Western Shore. Liberation of fry in Severn Run totalled 59,840,000.

3. CRAB

A major effort of the crab researches was concerned with the collection and interpretation of statistics on the crab catch in 1948. The data received was described in the *1947 Annual Report.* The data received from crab shippers and packers was summarized in a publication of the Department (No. 76. *The Maryland Crab Industry. 1948*). This bulletin summarizes the crab catch by month, by area and by gear, and presents

a far more accurate picture of fluctuations in abundance than has been possible heretofore. The report shows the daily catch of steady crabbers at fifteen places in the State, the quantity of hard and soft crabs caught in each part of the State by month and by the various methods, the quantity imported from outside sources and the approximate value of crabs to each part of the State.

A poll-type survey was made of the opinions of fifty-four packers and fifty-three shippers. These men were asked a series of questions relating to various crab conservation laws and to conservation philosophy. Their answers were frank and revealing, and can serve as useful guidance in administrative action. The results of the survey were incorporated in the publication named above.

The Chesapeake Biological Laboratory cooperated with the Blue Crab Technicians Committee of the Atlantic States Marine Fisheries Commission in an effort to make an intensive survey by dredge of the wintering crabs in the Rappahannock River, an area with conditions representing somewhat a miniature of the Chesapeake Bay. The survey was directed by the Maryland crab biologist. Because of unfavorable weather and gear deficiency (the unusually mild winter and consequent crab activity in early March made the dredge ineffective) the survey did not provide full data on crab distribution in relation to depth, temperature, bottom type, salinity and other factors. It was possible to obtain and tag 185 adult crabs and 158 juveniles. Returns from these tags began to accumulate in April. They promise to contribute further to the understanding of crab populations.

The returns from seventy releases of tagged crabs by several investigators from 1925 through 1946 were organized and studied. Six different methods of tagging had been employed and the efficiency of methods was compared in a publication (No. 78. *Comparison of Methods of Tagging the Blue Crab.* Ecology, Vol. 30, No. 3). The technique now in use is the best yet devised for adult crabs, that is, crabs that will not shed again. The marking of juveniles was studied through experiments with the injection of various non-toxic dyes under the shell of the crab. Trypan red, trypan blue, brilliant cresyl, methylene blue, Janus green, isamine blue were considered inadequate because they either killed the experimental animals or were not retained in noticeable concentrations. Neutral red, 1% in crab physiological salt solution, was concentrated by the crabs in the anterior portion of the ventral shell and was retained through one month by four crabs. This stain will be of some use in local experimental studies, but does not provide the needed technique for tagging large numbers of small crabs so that individual migrations can be traced.

A self-culling crab pot, which could be used to minimize the waste of small crabs in the potting operations, was developed and tested in the summer of 1948. Several wires were designed for use as top panels on standard pots made of one-inch chicken wire. The wires were tested as cages for crabs and on commercial pots set where small crabs were abundant. The best of these wires reduces the retention of small crabs by more than 90%, as compared with standard one-inch mesh pots. The data accrued have been made available to the Department of Tidewater Fisheries for possible use.

Several long-term activities were continued or expanded, including the tagging of large crabs, studies of the distribution and the biology of mud crabs, collection of crab literature, semi-quantitative analysis of local crab catches and sampling for juvenile crabs in Maryland waters.

4. DIATOMS

Diatom studies were continued from July to October on several important problems, some of which were in furtherance of work of the previous year, while some new phases were started. Much attention was concentrated on the diatom growth on the weed beds near the Laboratory Pier, and some preliminary measurements were initiated, to be continued another season, of the relative richness of the diatoms in this area of heavy growth, as compared with other areas, the open water, etc. This is an important investigation, as such an area represents an intensive feeding ground and shelter area for a great variety of shallow water marine life.

In the early fall, an exceptionally rich and heavy "bloom" of the interesting and odd diatom, *Nitzschia* (*Bacillaria*) *paradoxa* (Gmel.), gave fine opportunity for the continuation of studies on the process of locomotion in diatoms, and intensive observations on the nature and growth habits of this species.

A collecting trip to Chincoeague Bay to secure more materials from that area was less fruitful than had been expected because of the high turbidity of the water in this shallow area at the time. However, some materials were obtained. The effect of such turbidity on abundance and growth is one of the interesting aspects of the problem, toward which some attention may well be directed, since the visible penetration of solar radiation here is exceptionally small (but a few inches) and may either aid or inhibit the growth of certain species, depending on their light requirements.

Certain of the diatom investigations in progress were sufficiently complete to provide data for three papers presented at the 1948 meeting of the American Association for the Advance-

ment of Science. Two of them presented before the Phycological Society of America, of which abstracts were published in the Phycological News Bulletin No. 5, October, 1948, are titled as follows: (1) "A Method for Maintaining Designated Individual Diatom Cells in Open-Water Culture and Its Advantages for Studies of Growth and Reproduction"; and, (2) "Experiments Leading to Some Advances in our Knowledge of the Power of Movement in Diatoms, and a New Theory as to the Mechanism of Such Movement." Another paper, given before the American Society of Limnology and Oceanography, had to do with "Some Observations on Mass Occurrances of Diatoms, and an Hypothesis of Ascendency as an Important Influence Governing Them." This and the longer detailed papers on all three subjects are in preparation for the printer.

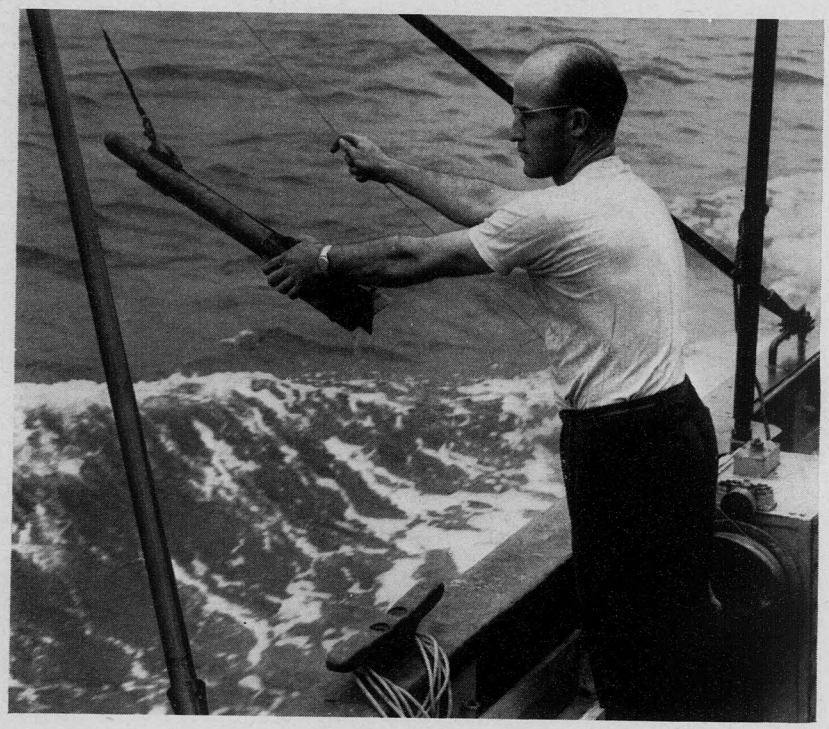
The heavy occurrence of *N. paradoxa,* earlier mentioned, together with a number of other variations, represented quite a departure from the type of growth found on the same weed beds in previous years—species of *Coscinodiscus* having been the decidedly dominant form for the past three years at least. The causes of such radical changes in the types of epiphytic growth, in an area where conditions, so far as can be determined, are not noticeably different from year to year, offer an important and interesting problem about which comparatively little is known thus far, but inasmuch as this is a nutritively rich area, should receive attention.

5. HYDROGRAPHY—CHESAPEAKE BAY INSTITUTE

The hydrographic program of the Chesapeake Biological Laboratory was curtailed during the year in keeping with the departmental policy of establishing, in cooperation with out-of-state agencies, a comprehensive attack on the chemistry and physics of the Bay. However, sampling at certain key stations was continued in which, throughout the year, weekly runs were made. Also, two transects of the Bay, one above and one below the mouth of the Patuxent River, were sampled periodically. A bathythermograph was used to record temperatures in all cases and it proved efficient and time-saving. A method for making quickly a permanent record of each bathythermograph slide was effected by using the slide as a photographic negative and projecting it through an enlarger. This procedure gives a graphic trace of temperature and depth which can be read easily.

Regular plankton tows and centrifuged plankton samples were taken and examined for cycles of abundance of the common food forms. At times of diatom bloom, special collections were made for the diatom study program. A four-year series of centrifuged plankton was put in order for quantitative and qualitative examination, a work that is now in progress.

The first year of operation of the Chesapeake Bay Institute, now ended, was marked by program formulation and effort at organization, the securing of personnel and obtaining specialized equipment with which to pursue the studies outlined. In late February, the Associate Director, D. W. Pritchard, took over the administrative affairs of the Institute and the professional staff, now eight in number, has reached almost full complement. A research vessel, the *R. V. Balanus,* was leased from the Woods



—*Photo by the Department of Research and Education.*

Fig. 12. Bathythermograph being lowered from the *Balanus* to obtain a temperature record of the waters of the Chesapeake Bay.

Hole Oceanographic Institution and assigned to an active observational program on the Bay (fig. 12, 13). The *Balanus* is on temporary assignment and will be used until replaced by a specially designed research vessel now under construction.

The problems that are being attacked by the Chesapeake Bay Institute are three-fold. Firstly, it is studying the overall physical and chemical hydrography which constitutes the marine habitat of the Chesapeake Bay, in order to obtain a picture of

the distribution and variation with time of the temperature, salt content, oxygen, plant nutrients, pH, turbidity and chlorophyl in the water of the Bay and its principal tributaries.

—*Photo by the Department of Research and Education.*

Fig. 13. Reading the reversing thermometers on Nansen bottles aboard the *Balanus*.

Secondly, the above distributions will be studied in their relation to such features as meteorological conditions, river run-off and tidal phenomena with the goal of establishing a procedure whereby the chemical and physical factors affecting life in the Bay may be forecast with reasonable accuracy. Thirdly, it will undertake the study of special problems involving the relationship between hydrography and specific biological phenomena which are of interest to fisheries biologists. To step up the effec-

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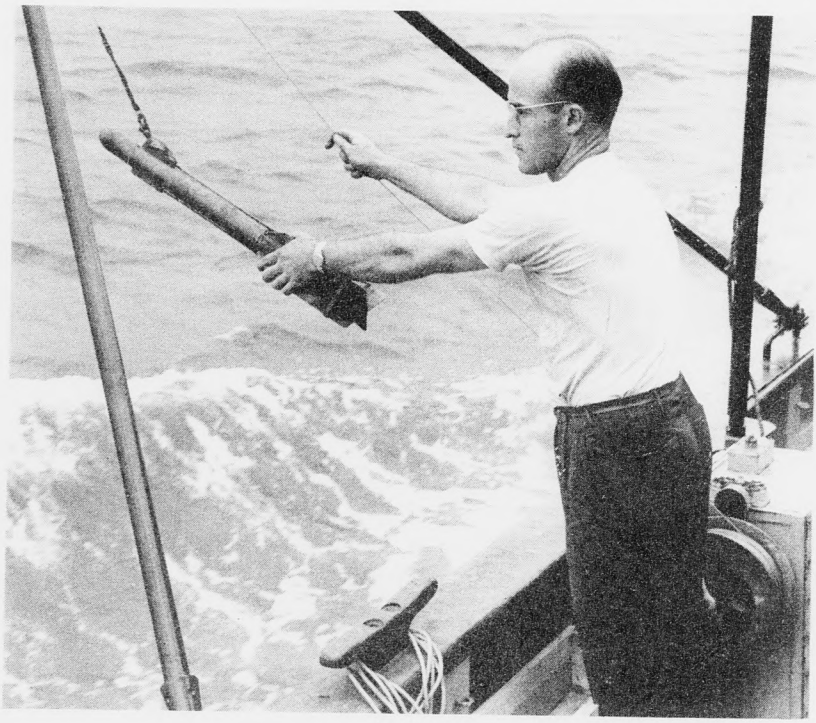

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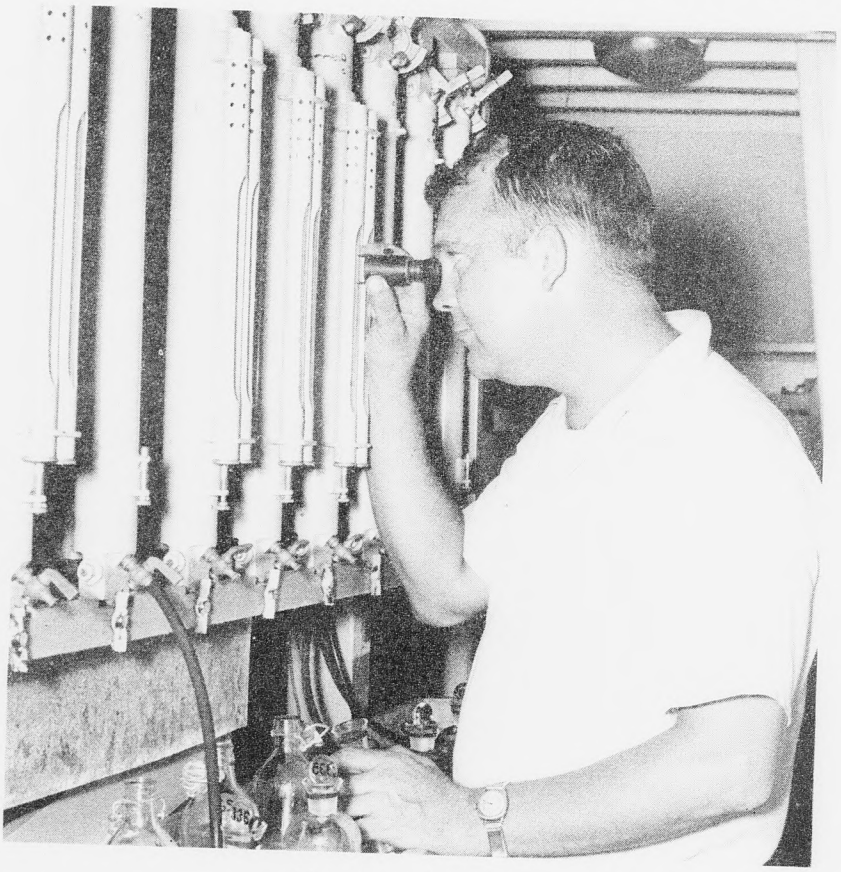

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tuation of the program, special recording equipment, designed for estuarine researches, is being constructed. It is expected that this automatic gear will markedly improve the observational techniques now employed in that the extent of data that can be obtained will be increased many fold.

Work on the first objective is well under way. One serial survey of the Bay has been completed. Water samples were obtained and analyzed from several depths at 120 stations on the Bay and its tributaries. Similar surveys will be made at one to two-month intervals. Most of the chemical analyses were made by technicians in the laboratory aboard the *Balanus* (fig. 13) within a few minutes from the time the samples were taken from the water. The remaining analyses were done in the chemical laboratories at The Johns Hopkins University.

The Chesapeake Bay Institute is a division of The Johns Hopkins University established by state grants from Virginia, through the Virginia Fisheries Laboratory, and Maryland, through the Chesapeake Biological Laboratory, and a grant from the Office of Naval Research of the U. S. Department of Navy. The purpose of the three sponsoring organizations in establishing the Institute at The Hopkins was to provide, at a university of national reputation, an organization for the study of physical and chemical hydrography of coastal and estuarine waters in general, and the Chesapeake Bay in particular. The program embraces, in addition to the intense estuarial studies, an educational approach to the problem, through courses at the advanced levels in the Institute, in order that more and better trained scientists may become available to explore a field thus far rather largely neglected, the extensive embayed waters so significant in connection with food production.

6. PATAPSCO PROJECT

The Baltimore Harbor study was intensified during the year. This was the second year of a project intended to develop fundamental technical information regarding the 13-mile stretch of the Patapsco River that comprises Baltimore Harbor. Chemical and bacteriological analyses of water samples collected regularly from established stations over the harbor were continued. A large number of such samples must be collected and examined over a period of time to smooth out fluctuations introduced by such variables as winds, tides, and seasons. Consideration of these data at the close of field operations will enable evaluation of the variables.

The field work completed during the year emphasized the difficulty of obtaining comparable information over the entire harbor area due to its size and the time required to complete a

given set of observations. Similar work elsewhere has indicated the value of use of kinematically similar models for synoptic study. Consideration was given to the possibility of constructing such a model of Baltimore Harbor. The feasibility of such procedure was demonstrated and further work is progressing along this line. As reported last year, winds play a dominant role in transporting water into and out of the estuary. An adequate quantitative study under field conditions of mechanisms involved has proved to be impracticable. It is anticipated that operation of a suitable model will enable greater appreciation of water movements within the harbor.

—*Photo by the Department of Research and Education.*

Fig. 14. View showing concentration of industrial activities on the north side of Curtis Bay adjacent to Baltimore Harbor.

Investigation of the iron content of harbor bottom muds was continued. This phase of the program was undertaken in order to determine the areas in which deposition of iron-bearing industrial wastes occur. This material is discharged into the harbor in large volumes and it appears that most of it is precipitated within the Port in conformity with the chemical and physical analyses of harbor water.

It has been estimated that the silt load of the Patapsco River approximates 600,000 cubic yards annually. That much of such material is deposited within the harbor is supported by the fact that channel dredging in the harbor for the six-year period, 1940 through 1945, averaged 500,000 cubic yards annually, according to the U. S. Corps of Engineers, Department of the Army.

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Harbor area-volume relationships were computed during the year. It was found that the harbor surface area at mean low water is 39.8 square miles and that the Port has a volume of over 15 billion cubic feet below mean low water. These data also disclosed that channel capacity alone exceeds the tidal prism volume. This is additional evidence in support of the hypothesis

—*Photo by the Department of Research and Education.*

Fig. 15. Making current observations in the Baltimore Harbor.

that the tidal water which enters Baltimore harbor from Chesapeake Bay is largely unavailable for waste dilution.

A study was completed of field conductivity measurements made on harbor water and it was found that this determination could be relied upon as a direct measure of chlorinity only in main channels. The presence of various industrial wastes in areas of high concentration interefered seriously with this means of quickly determining the concentration of salt water at any given location.

Coliform organisms, commonly used as an indicator of sewage pollution, disappear from brackish waters at higher rates than those expected on the basis of dilution encountered or normal mortality rates as measured in the laboratory. One of the

possible mechanisms involved in the die-off of coliform organisms in estuarine waters has been brought under detailed study. The mechanism being investigated is concerned with adsorption of bacteria to particulate matter, muds and silts, and the flocculation and precipitation of the silt on mixing with saline waters. Review of bacteriological analyses of harbor water disclosed that 24-hour presumptive coliform indices agree closely with confirmed results which required several days to obtain. Since the latter are relatively costly in terms of time and money, this finding is of significance.

Arrangements were completed and work begun on a wastes survey at an industrial establishment which is the largest single contributor of wastes to the harbor. This and other such studies will be completed during the coming months as part of the work requisite to ascertaining the volume and characteristics of wastes being discharged to the Harbor.

Liaison with interested local, State and Federal agencies was maintained during the year and a growing interest in the harbor project was evinced by many of the public and industrial organizations connected with the Port of Baltimore.

7. OTHER STUDIES

The major studies of a biological nature pursued by the Department have been indicated. In addition, there have been several studies of less immediate significance, but of lasting importance, carried on during the year. Among these were the continued collection and analysis of marine, fresh-water and land fungi of the region, the abundance of new year classes of fish, bird censusing and food habits of certain game forms. There was initiated during the year a preliminary study of the comparative richness of planktonic materials in waters along the Atlantic Coast. Woods Hole, Massachusetts, and the Solomons Island, Maryland, region were sampled and the plankton material determined to test out the feasibility of expanding this work to include key points between Maine and Florida, inclusive. A number of advanced students from universities did research work in several directions, mainly on marine organisms.

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C—NATURAL RESOURCES INVENTORY

1. MONOCACY WATERSHED

A preliminary survey of the biological resources of the Monocacy River watershed, located mainly in Frederick and Carroll counties, Maryland, was accomplished during 1948. A brief analysis of the data obtained follows:

Forests: The forests cover twenty-five per cent of the area of the Monocacy watershed and are growing at the rate of 3.5 per cent annually; or, in more concrete figures, 49 cubic feet per acre per year. Practically 100 per cent of the forests of the area are of the hardwood species, and the average acre of forest contains 1,416 cubic feet of wood, of which 74 per cent is of oak species. The annual increment of 49 cubic feet per acre as shown in this survey is somewhat above the statewide figure of 40 cubic feet per acre indicated in the Bowman Report.[1]

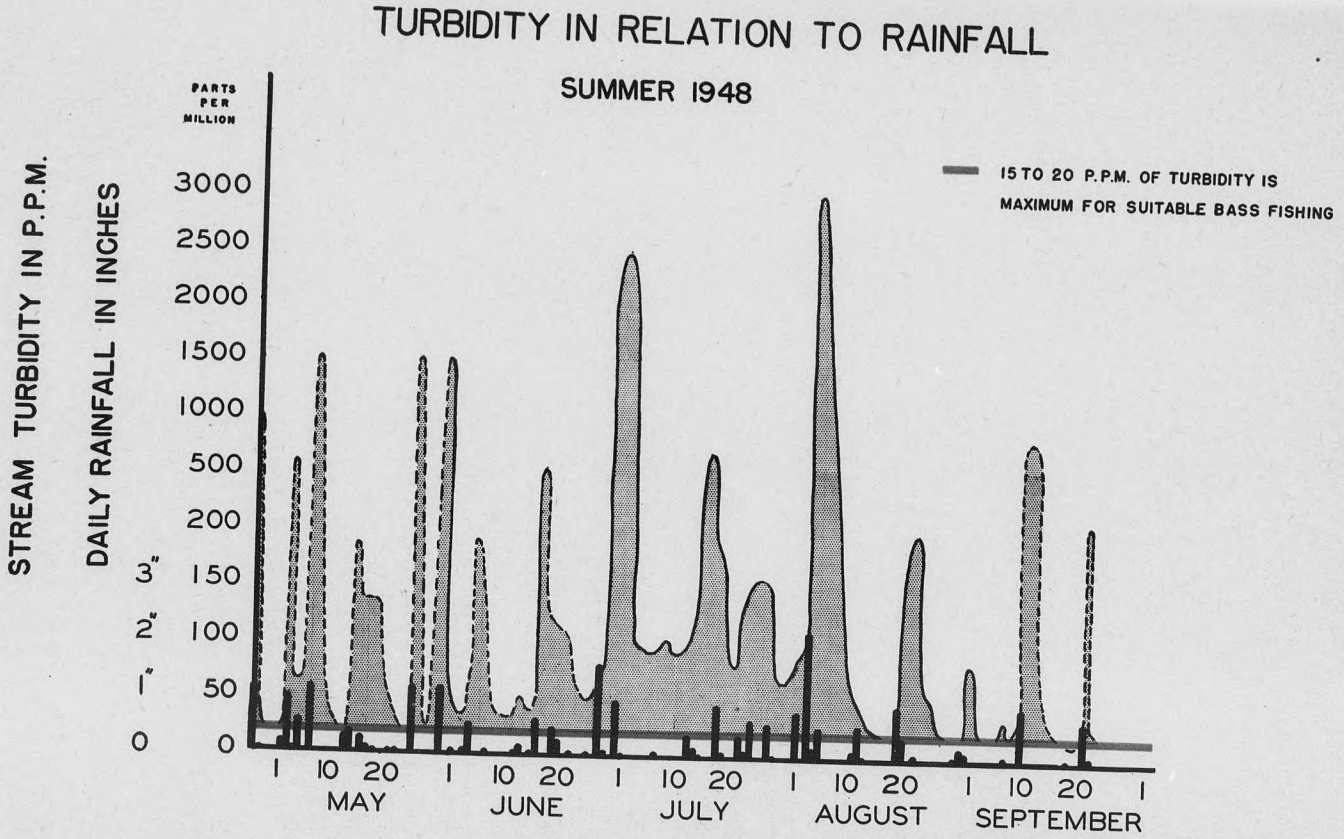
Water: The Monocacy drains a total of 970 square miles, 742 of which are located in Maryland. The main stream is 58 miles long within the State. Portions of three counties are drained by the Monocacy, 500 square miles in Frederick County, 212 square miles in Carroll County, and 30 square miles in Montgomery County, Maryland. Stream conditions were found to be poor as compared with many other Maryland rivers. The be poor as compared to many other Maryland rivers. The Monocacy carries at least a partial silt load throughout the year. This muddy condition was determined to be caused by the large number of tributaries that drain areas denuded of forest cover and, also, because only 20 per cent of the watershed is practicing soil conservation methods. As a result of this condition, the opening of the bass season on the stream finds it running brown with silt. On only eight days between July 1 and October 1 were the turbidity readings reduced to a point that was considered suitable for good bass fishing (fig. 16).

The general water quality for the river was found to be average. Total alkalinity ranged from twenty to seventy parts per million which is somewhat softer than average. There are communities along the stream with sewage disposal plants of varying effectiveness which threaten fish populations and public health in their immediate vicinities. Pollutants are also introduced into the main stream and its tributaries by food packers. Many points on the stream are unfit for bathing and boating, while its water in certain areas can not be used for drinking purposes and its aesthetic value is virtually lost.

Fish: Information regarding anglers' success, fish growth and reproduction was collected during the survey of the River. These

[1]Report of the Maryland Commission on Conservation of Natural Resources, December 1, 1948.

TURBIDITY IN RELATION TO RAINFALL



—*Drawing by the Department of Research and Education.*

Fig. 16. Rainfall, turbidity and bass fishing conditions in the Monocacy River, 1948.

findings are essential to future fisheries management. Creel census and fishermen counts produced the following estimates.

Number of fishermen (April through September)		12,000
Average time spent fishing per man		6.25 hours
Fish caught per man per hour—		
Catfish family	0.16	
Sunfish family	0.13	
Bass (all sizes)	0.03	
Others	0.07	
Total per man per hour		0.39
Number of fish taken by anglers—		
Catfish family	16,000[1]	
Sunfish family	6,000	
Smallmouth bass	920	
(legals—340; sub-legals—580)		
All others	7,800	
Total number taken by anglers		30,720

[1]Fish taken by bush bobbers—2,000 catfish.

The only game fish present in the Monocacy is the smallmouth bass. Pan fishes included rock bass, yellowbelly sunfish and pumpkinseed. Food fish taken included channel catfish, yellow and brown bullheads, eastern redhorse, white sucker, fall-fish, eels and hog suckers. Twenty-three species of forage fish, including minnows, darters and dace, were found (fig. 17). Growth studies indicated that the smallmouth bass reach legal size in

—Photo by the Department of Research and Education.

Fig. 17. Fifty-foot haul seine being operated at a Monocacy River sampling station.

their third year. This figure represents average to good growth. Since the River is very muddy, success of spawning is questionable. Areas suitable for spawning are believed to be adequate for the present population. The heavy silt load in the stream usually present during the height of the bass spawning season may be a substantial factor in the apparent failure of bass spawning effort.

Game Birds and Mammals: This phase of the inventory remained in the stage of organization. A portion of the area was game cover-mapped and game kill records were taken from a random sample of hunters. A list of resident game species whose ranges fall in the Monocacy watershed was prepared.

2. STATEWIDE PROJECTS

Water quality sampling stations were visited twice during the year and information was collected regarding the physical and chemical conditions found in the major and type streams indicated in the 1948 Annual Report. One check was made during the critical summer months of July and August in order to obtain information on limiting factors caused by pollution and marginality of water as it concerns fish productivity.

Plans, field data forms and field checking were completed in preparation for the combined forest-wildlife survey which is scheduled to begin at the start of the new fiscal year. New aerial photographs are available for the three western counties, and parts of two other counties. Information derived from the survey will provide a comprehensive body of knowledge concerning areas and production of the commercial and non-commercial forested regions by forest type groups and by stand size classes. The wildlife phase of the survey is intended to develop knowledge about the areas of different types of game cover, and the amounts of woodland border, fencerow and "edge" for the various physiographic regions.

Modified commercial trap nets were placed in two bodies of water, namely, Tridelphia Reservoir and Conowingo Reservoir, for several weeks during the spring of 1949. A check was made on the relative abundance of fishes present, their size frequency, and their growth. This operation will be repeated during the coming fall in order to check the information available, and to find possible trends in the populations.

A typical Eastern Shore impoundment, Harmony Pond, Caroline County, was drained during the late summer months of 1948 to determine the kinds of fish present and their growth.

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The fish recovered, in addition to the largemouth bass stocked in the pond were as follows:

Common Sunfish—*Lepomis gibbosus* (juveniles)
Sphagnum Sunfish—*Enneacanthus o. obesus* (adults)
Chubsucker—*Erimyzon o. oblongus* (young adults)
N. Brown Bullhead—*Ameiurus n. nebulosus* (young)
Golden Shiner—*Notimigonus c. crysoleucas* (juveniles)
Redfin Pickerel—*Esox americanus* (adult)
Chain Pickerel—*Esox niger* (juvenile-adult)

The pond was refilled and restocked with known number and kinds of fish. The species and their growth will be checked at successive periods over the next three years.

Hunter success was determined from a random sample of the sportsmen within a certain area. Hunter-kill information for 1948-1949 was obtained by means of a questionnaire and follow-up card from the hunters in Baltimore, Harford and Cecil counties for use by the Department of Game and Inland Fish in judging the relative success of the open season. One means of obtaining trends in game populations is to set up sample areas throughout the State, cover map them and check the population by contacting local observers. A project of this type was started and the cooperation of the U. S. Soils Conservation Service was solicited. Typical farms from each county were chosen, one for its good conservation farming practices and another for its average farm practices. It is anticipated that population census coupled with hunter-kill statistics collected over several years will provide a good criterion of the ups and downs of the game birds and mammals and suggest remedies where needed.

During the 1948 deer season, investigators were stationed at three Western Maryland checking stations where pertinent information was obtained from 105 bucks killed in Allegany and Garrett counties, which represents 15.1% of the total number of bucks taken in that region. The data was analyzed by the method of Cahalane, that is, for aging deer by antler beam measurements. The figures for the one year indicated that the herds from different regions are composed of different age groups and sex ratios. For example, at Swallow Falls, many does were seen by hunters and a greater percentage of one-and-a-half year old bucks was shot. At Meadow Mountain, fewer does were seen by hunters and the percentage of one-and-a-half year olds was lower. Garrett County showed a higher percentage of this age killed than did Allegany County.

D—WEATHER SERVICE

The State Weather Service, Department of Research and Education, augments and supplements the broad services of the U. S. Weather Bureau. By this joint action, agricultural and business interests in all parts of the State have available detailed warnings and forecasts of weather conditions. In addition, specialized research services to agricultural, industrial, and other agencies are provided, within limits, as need arises.

Climatic details depend to a great extent on the geography of a region. The topography of the State of Maryland varies from the low coastal section of the east to the mountain plateaus of the west. The coastal section is near the Atlantic Ocean and is indented by a few large and many small bodies of water. These bodies of water tend to moderate the extremes of temperature, whether hot or cold, as well as increase the water vapor content of the air. In the mountainous sections, and to a lesser extent in the Piedmont region of the State, temperatures vary considerably between the valleys and the higher elevations. The general direction of storm movement, whether parallel or perpendicular to the mountain ranges, has pronounced effect on the amount of precipitation that falls on an area. This is illustrated by the average annual rainfall at Oakland, forty-seven inches, in comparison with that at Westernport, some ten miles to the east, where the fall is thirty-six inches. Thus, to provide the detailed data frequently requested, a network of observation stations is maintained.

The number of weather stations decreased during the war due to the conditions at that time. However, during the last three years they have been increased to the present total of eighty-five. These stations are operated by observers who have an interest in weather and who serve on a voluntary basis without pay. Certain of the stations are operated by agencies of the Federal, State and local governments. Forms containing data on observed weather are mailed weekly or monthly to the Baltimore office. These data serve as a basis and guide in determining the suitability of given areas for specific business ventures and agricultural crops. Also, the reports serve in the study of the development of crops, the control of insects and diseases, and they provide general information on the climatic variations over the State for engineering, transportation and other uses. This phase of the Department's work, in cooperation with the U. S. Weather Bureau, is providing data which is valuable throughout the State (1) in making special studies of its varied climatic conditions and their influence upon the welfare of the people and, (2) in improving forecasting techniques for warnings to agricultural, fishing, transportation, and general business interests.

The equipment at practically all the stations consists of maximum and minimum thermometers for recording the daily extremes of temperatures, a rain gage in which precipitation can be measured to within one one-hundredth of an inch, and an instrument shelter for housing the thermometers. All the necessary forms, supplies and instructions are provided to the observer who makes one observation daily, usually in the late afternoon, of the following factors: the highest and lowest temperatures for the preceding 24 hours; the temperature at the time of the observation; the precipitation for the preceding 24 hours; and, the types of weather such as snow, fog, thunderstorms, frost, etc., as they occur. At certain stations, special notes on the condition of crops and the effects of weather on crops are added. Immediate use of these reports is made in preparing and publishing a weekly summary of weather and crop conditions through the cooperative activity of the Maryland State Weather Service, the U. S. Weather Bureau, the State Department of Markets, and the U. S. Department of Agriculture, Division of Statistics. Thus, producing, canning and transportation interests are kept advised as to the crop and weather conditions over the State.

Through a cooperative agreement among the State Weather Service, the U. S. Weather Bureau and the State Police, forecasts and warnings for each county are disseminated daily over the teletype system of the last named agency. The forecasts are transmitted to all State Police barracks about 8:30 a. m. At the barracks, they are made available to County Agents, newspapers and radio stations for a further dissemination to agricultural, commercial and other interests. Thus, detailed forecasts are provided daily to the people of every county for use in planning operations in their particular area.

E—EDUCATION

The conservation education program of the Department continued during the year to concentrate on training in-service teachers. A series of two-and-a-half-day workshops was held at the Chesapeake Biological Laboratory during July and August, 1948. Each shop group was given an intensive, rounded session in principles and practices, together with time during which the registrants, divided into committees, prepared their own answers to the problems of taking conservation to the class room. Problems considered were (a) at what levels should it be taught, (b) in what subjects, (c) by what means and materials, and (d) by whom? The reports of these four workshops were summarized to get a comprehensive outline of the teachers' impressions in the field.

The 1949 workshop series began with a session for colored teachers at Cambridge on June 14-16, which was attended by fifty teachers. The other major training program for in-service teachers, a three semester-hour course accredited at The Johns Hopkins University, was offered during the fall semester at Baltimore, Bel Air and Elkton. Plans have been developed looking to providing this course in the fall in Talbot and Wicomico counties and during the spring semester, 1950, in St. Mary's, Charles and Carroll counties and Baltimore City.

Both the workshops and the credit course provide field trips to see, first hand, the problems of soil, water, forest, game and marine resources. In both programs, the specialists of other agencies of the Board of Natural Resources and the State Soil Conservation Service assisted the Department's staff. The response of teachers who participated was unanimously favorable and appreciative.

In addition to the scheduled workshops for in-service teachers, there were special programs at Solomons for (1) the Supervisors of Colored Schools from all the counties, under the leadership of Mr. Paul Huffington, Supervisor of Colored Schools, State Department of Education, (2) student groups from certain colleges in the region and other like sessions. Field contacts and lectures were provided to school groups on several occasions during the year by members of the staff. The Education Assistant served as consultant for the committee considering natural resources during the three-day State-wide School Conference in April, and cooperation with the schools and school officials has progressed favorably.

Adult education work has been carried on at Solomons with such groups as the Anne Arundel County Fish and Game Association, Maryland Sportsmen's Luncheon Club and others in which field demonstrations were used. Also, this Department cooperated with the Department of Tidewater Fisheries to set up an extended training course for their enforcement personnel, of whom twenty-five attended at Solomons in 1948.

A series of two-day sessions at the Solomons Laboratory for pupils from Baltimore high schools was started on a trial basis during the spring of 1949. These sessions were arranged at the request of the City schools under their "Outdoor Education Program." From each of five City high schools, a group of twenty-eight students was selected on the basis of merit from the science classes and taken to the Chesapeake Biological Laboratory to see the conservation problems at first hand and to learn, from seeing and doing, about resources and their use. The programs were received very favorably by the high school people and, while this Department cannot continue work at the

high school level because of various limitations of staff and budget, it is hoped that the City and county schools will follow up the success of this experimental series with regular programs of their own.

The Department continued to work in an advisory capacity and to offer demonstrations to the Students Marine Conservation Society, an extra-curricular boys' club of the Calvert County High School. These boys are studying the problems of conservation and utilization of natural resources, especially of seafoods. Membership in it is limited to those who have access to tidewater, preferably sons of watermen, in order that they may carry out experiments and observations of their own. Some of the projects now under way include following up the growth of oysters on the Club's two planted bars, checking growth and mortality rate of oysters on experimental trays located at various points, and periodic observations of water temperature and salinity, etc., at different locations.

A new concept of practical conservation education is growing in Dorchester County under the Superintendent of Schools, Mr. W. T. Boston. This Department is working closely with Mr. Boston on plans to develop a vocational high school dealing with the water, marshland, forest and wildlife resources of southern Dorchester County, from which most of the people of the area earn their living. The central idea would parallel the usual vocational agriculture curriculum but concentrate even more on training pupils to live a fuller and better life with and on the community's resources.

Other projects of an educational nature included the development of visual aids, the handling of publications and requests for information and exhibits at points of strategic interest, such as community and sportsman shows. In response to numerous requests by teachers for more information and materials, a bibliography of books, pamphlets and visual aids on conservation was compiled during the year. It is hoped that this work will be revised and printed early in the fall for distribution to teachers of the State. New equipment is available for the taking of pictures and it is planned to extend the visual aids of the Department, including moving pictures and slides, now so deficient.

F—PUBLICATIONS

The Department publishes its work in three series. A monthly six-page paper *The Maryland Tidewater News,* is issued to the State's licensed watermen, to its conservationists and educators, and to the public and school libraries. Bulletins are

issued relating to conservation problems and resource use in an *Educational Series* intended primarily for school use and adult education purposes. The findings from the research program are issued in a *Publication Series,* the different issues of which are exchanged with research workers, laboratories and scientific institutions in which related work is carried on. Certain of these reports are first published in the specialized journals of the fields involved.

During the year being reported, Volume V, *Maryland Tidewater News,* was issued, while seven major contributions and two educational bulletins were published. All of the publications to date of the Department and its subsidiary agency, the Chesapeake Biological Laboratory, are listed here:

DEPARTMENT OF RESEARCH AND EDUCATION
Solomons, Md.

Below are listed by titles and authors the publications, both reprinted and regular, of the Department of Research and Education and its Chesapeake Biological Laboratory. Numbers 1-41 were printed as *Contributions.* Thereafter, they were issued as *Publications.* This series is to be continued in reporting results from the Department's research program. Future treatises dealing with education and economic problems will be issued in *Educational Series,* 21 of which are currently listed.*

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1 Aspects of the Oyster Season in Maryland—Truitt, R. V., 1927.
2. The Fishes of Maryland—Truitt, R. V., B. A. Bean and H. W. Fowler, 1930.*
3. Recent Oyster Researches on Chesapeake Bay in Maryland—Truitt, R. V., 1930.
4. The Oyster and the Oyster Industry of Maryland—Truitt, R. V., 1931.*
5. Scientific Fisheries Work in Maryland—Truitt, R. V., *Trans. Am. Fish. Soc.,* 1932.*
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7. Striped Bass Investigations in the Chesapeake Bay—Truitt, R. V. and V. D. Vladykov, *Trans. Am. Fish. Soc.,* 1937.
8. 1936 Annual Report, Chesapeake Biological Laboratory—Truitt, R. V., 1937.*
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10. Variations in Growth Indices of *Mya arenaria* L. on the Atlantic Coast of North America—Newcombe, C. L. and H. Kessler, *Ecology,* 17: No. 3., 1936.*
11. The Oyster Packing Industry of Baltimore—Nichol, A. J., 1937.
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13. Variations of *Dactylometra quinquecirrha*—Littleford, R. A. and R. V. Truitt, *Science,* 1937.*

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14. Growth Indices of *Littorina irrorata*—Newcombe, C. L., *Biologia Generalis*, Vol. XIII., 1937.
15. Variations in Growth Indices of *Venus mercenaria* L. From Widely Separated Environments of the Atlantic Coast—Newcombe, C. L., S. J. Thompson and H. Kessler, *Can. Jour Res.*, Vol. 16, 1938.
16. Notes on Maryland Algae—Bold, Harold C. *Bull. Torrey Bot. Club—Can Jour. of Res.*, 1938—Joint contr. with University of Maryland.
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18. Migration in the Striped Bass, *Roccus lineatus*, of the Chesapeake Bay—Vladykov, V. D. and D. H. Wallace, *Trans. Am. Soc.*, 1937.*
19. Oxygen-Poor Waters of the Chesapeake Bay—Newcombe, C. L. and William A. Horne, *Science*, Vol. 88, 1938.*
20. The Relative Growth of Parts in the Blue Crab, *Callinectes sapidus* Rathbun—Gray, Ellen H. and Curtis L. Newcombe, *Growth*, Vol. 2, 1938.*
21. Studies on the Physics and Chemistry of Estuarine Waters in Chesapeake Bay—Newcombe, Curtis L., William A. Horne and Boland B. Shepherd, *Journ. Mar. Res.*, Vol II, 1939.
22. 1937 Annual Report, Chesapeake Biological Laboratory—Truitt, R. V., 1938.*
23. The 1938 Program of the Chesapeake Biological Laboratory—Newcombe, C. L., *Collecting Net*, 1938.*
24. Studies of Moulting in *Callinectes sapidus* Rathbun—Gray, Ellen H. and Curtis L. Newcombe, *Growth*, Vol. II, No. 4, 1939.*
25. Progress of the Rock and Shad Research Work at the Chesapeake Biological Laboratory—Wallace, D. H. and R. V. Truitt, *Trans. Am. Fish. Soc.*, 1938.*
26. Sport Fishing in Maryland—Truitt, R. V., 1938.*
27. Our Water Resources and Their Conservation—Truitt, R. V., 1939.*
28. The Distribution of Phosphates in the Chesapeake Bay—Newcombe, Curtis L. and Andrew G. Lang, *Pro., Am. Phil. Soc.*, Vol. 81, 1939.*
29. Distribution of Rathkea—Littleford, Robert A., *Nature*, Vol. 143, 1939.*
30. 1938 Annual Report of the Chesapeake Biological Laboratory—Truitt, R. V., 1939.*
31. The Life Cycle of *Dactylometra quinquecirrha*, L. Aggassiz in the Chesapeake Bay—Littleford, Robert A., *Biol. Bull.*, Vol. LXXVII, 1939.
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37. An Experimental Study of Certain Quantitative Plankton Methods—Newcombe, C. L., Robert A. Littleford and Boland B. Shepherd, *Ecology*, Vol. 21, 1940.

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40. 1940 Annual Report, Chesapeake Biological Laboratory—Truitt, R. V., 1941.*
41. Maryland Commercial Fish Hatchery Operations, 1940—Wallace, David H. and R. V. Truitt, 1941.*
42. Seafood and the Diet—Lemon, J. M. and R. V. Truitt, 1941.
43. Studies of the Effects of Industrial Pollution in the Lower Patapsco River Area—Olson, R. A., 1941.
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45. A Rapid Response Thermocouple Unit of High Sensitivity for the Determination of Temperature Stratification in Natural Waters—Olson, R. A., 1941.
46. Ovarian Growth and Ovulation in the Mature Blue Crab, *Callinectes sapidus Rathbun*—Hard, W. L., 1942.
47. 1941 Annual Report, Chesapeake Biological Laboratory—Truitt, R. V., 1942.*
48. Control of Fishing Intensity in Maryland—Hammer, Ralph C. and R. V. Truitt, *Trans. Am. Fish. Soc.*, 1942.*
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50. Observations on the Feeding Habits of Marlin—Wallace. David H., 1942.*
51. Ecological and Life History Aspects of the Red-Jointed Fiddler Crab, *Uca Minax* (LeConte), in the Region of Solomons Island, Maryland—Gray, Ellen H., 1942.*
52. Experimental Sponge Crab Plantings and Crab Larvae Distribution in the Region of Crisfield, Maryland—Graham, James G. and G. F. Beaven, 1942.*
53. A Study of the Crab Pot as a Fishing Gear—Davis, Charles C., 1942.*
54. Maryland Commercial Fish Hatchery Operations, 1941-42—Truitt, R. V., 1942.
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56. 1942 Annual Report, Chesapeake Biological Laboratory—Beaven, G. F., 1944.
57. Indications of Compensatory Growth in the Striped Bass, *Roccus saxatilis* Walbaum, as Revealed by a Study of the Scales—Tiller, Richard E., 1943.
58. The Larval Stages of the Calanoid Copepod *Eurytemora hirundoides* (Nordquist)—Davis, Charles C., 1944.
59. Ebullition of Gases from Marsh and Lake Waters—Conger, Paul S., 1944.
60. Maryland Commercial Fish Hatchery Operations. 1943—Hammer, Ralph C., 1944.
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62. Histochemical Observations on Glycogen in the Liver of the Blue Crab, *Callinectes sapidus* Rathbun—Sister Leonide Regan, 1944.
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65. Some Observations on Seasonal Variations in Plankton Population, Patuxent River, Maryland, 1943-1945—Morse, Dorothy Clum, 1947.
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67. Fresh-Water Dinoflagellates of Maryland—Thompson, R. H., 1947.
68. Effect of Susquehanna River Stream Flow on Chesapeake Bay Salinities and History of Past Oyster Mortalities on Upper Bay Bars—Beaven, G. Francis, 1947.
69. Maryland Commercial Fisheries Statistics, 1944-1945—Hammer, Ralph C., Harry A. Hensel and Richard E. Tiller, 1948.
70. Effects of Small Underwater Explosions on Oysters, Crabs and Fish—Staff, Chesapeake Biological Laboratory, 1948.
71. An Ecological Study of Seasonal Distributions of *Ostracoda*, Solomons Island, Maryland, Region—Tressler, Willis L., and Essie M. Smith, 1948.
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2. The Maryland Management Plan and the Rock Fishery—Tiller, R. E., 1944.
3. Maryland Laws Governing the Board of Natural Resources and Associated Departments, with Interstate Compacts on Natural Resources—Bayliff, William H., Ed. 1944.
4. Symposium—1944 Maryland Conservation Forum.
5. The Maryland Management Plan and the Shad Fishery—Tiller, R. E., 1944.
6. Fishery Management Plan Productive—Tiller, R. E., 1944.
7. The Oyster—Truitt, R. V., 1944. *bios:* Vol. XV, No. 3. October, 1944.
8. Maryland's Oyster Problem—Beaven, G. F., 1945. *French-Bray Co.*

9. Maryland Stream Flow Records—Singewald, J. T., Jr., 1945.
10. Maryland Conservation Officials and Organizations. 3rd Edition—Bayliff, William H., 1948.
11. Maryland Commercial Fish Hatchery Operations—Hammer, Ralph C., 1946.
12. Trees of Maryland—Kaylor, Joseph F., 1946.
13. Ground Water in the Baltimore Area, Maryland—Bennett, Robert R., 1946.
14. Utilization of Maryland Marine Products—Miller, T. M., 1947.
15. Maryland Commercial Fish Hatchery Operations—Coker, Coit M., 1947.
16. Annual Report, 1946—Truitt, R. V., 1947.
17. Maryland Forests and Forestry—Burns, Findley, 1948.
18. Maryland's Commercial Fishing Gears—Coker, Coit M., 1949.
19. Inventory Plan, Maryland Natural Resources—Truitt, R. V., 1948.
20. Annual Report, 1947—Truitt, R. V.
21. Maryland Farm Woodlots—Bond, Adna R., 1948.
22. Annual Report, 1948—Truitt, R. V., 1949.

G—ACKNOWLEDGEMENTS

The Department's program was furthered to a marked extent during the year by several workers and organizations not regularly associated with it. The Bethlehem Steel and the Seidel Manufacturing companies continued to supply advice and material for the study of mesh sizes in relation to crab escapement from crab pots. This gear, now used generally, and employing one-inch meshing, destroys a considerable quantity of small and illegal crabs. Bethlehem Steel, E. I. du Pont de Nemours and the Zirconium companies made substantial contributions in support of the Patapsco Project. The Conowingo Power Company again supplied space, facilities and equipment for studies on the Subsequehanna River. Several radio stations gave time to the Department for report and discussion programs.

A number of persons worked at the Laboratory over varying periods during the year, all of whom studied in their special fields of interest. The Smithsonian Institution continued its interest in the study of the diatom flora of the Chesapeake Bay, through the assignment of Mr. Paul S. Conger to the project at the Chesapeake Biological Laboratory during the summer season. Dr. Robert Littleford assigned for the summer two of his graduate students in the University of Maryland to the natural resource survey. Dr. James B. Lackey, of the Blakiston Company, initiated a study of the relative abundance of plankton in the Chesapeake Bay as compared with certain other points along the Coast. Dr. Rufus H. Thompson, University of Kansas, continued his analysis of algal material collected in Maryland. Dr. John S. Karling, Purdue University, made further collections of Chesapeake area fungi and is continuing their classifi-

cation. Miss Ann E. O'Rourk, Western Maryland College, continued the fish parasite survey started by her during 1948, and Miss Cynthia Wilmer resumed oyster studies pertinent to setting in the St. Mary's River.

Experimental oyster seed from the Gulf region were provided by Dr. Malcolm Owen of the Louisiana Department of Wildlife and Fisheries, and by Dr. Sewell Hopkins of the Texas A and M Research Foundation. Mr. Frank I. Ineson, Mr. H. W. Camp, Jr., and Mr. Roland Fergerson, of the U. S. Forest Service, aided materially in the formulation of plans for the forest-wildlife survey. Mr. John M. Lester, Engineer, Washington Suburban Sanitary Commission, made a substantial contribution in the form of boats, help and facilities for fish sampling in the Tridelphia Reservoir. The Johns Hopkins University contributed to the Department's program in several directions. The cooperative Chesapeake Bay Institute became functional during the year on the University's campus, while the Patapsco Project was furthered there. McCoy College of the University sponsored and accredited the three-semester-hour course, "Conservation of Our Natural Resources." Several projects were continued with the Fish and Wildlife Service, including the operation of the Fort Belvoir Hatchery and the oyster research program centered at Annapolis under Mr. James B. Engle.

Excellent relationships existed between the different agencies of the Board of Natural Resources, the Soil Conservation Service and the Department. The Department of Forests and Parks heartily supported the aerial survey of forests and aided in the teaching and field program in conservation education. Likewise, the Department of Game and Inland Fish contributed to the aerial survey of game covers in the State and to the teaching program. In addition, through the interest of Director Ernest A. Vaughn and Mr. Edwin M. Barry, Chief, Game-Fish Management, the wildlife inventory was advanced, especially through the help of their field personnel. A pond for shad study was made available by this agency. Dr. Joseph T. Singewald, Jr., Director, Department of Geology, Mines and Water Resources, and his associates continued their interest and help in the program, especially the educational features. Mr. Edward M. Davis, State Conservationist, Soil Conservation Service, cooperated fully in the workshop and classroom teaching. The Director, Department of Tidewater Fisheries, Mr. David H. Wallace, provided facilities for certain features of the field work, participated in the educational program and advised with the Department's staff as requested in connection with the researches and with the application of findings from same. The personnel of the Department of Tidewater Fisheries aided greatly in the effectuation of the Bay-study program.

The help of the State's leaders in public education was marked in connection with workshops, classes and adult education programs. Several county superintendents of education sponsored such work. Professor Harry R. Hughes, Superintendent of Schools, Calvert County, fostered the organization and development of a boys' group to work in conservation much as the Future Farmer groups work in agriculture. This group, the Students Marine Conservation Society, is functioning effectively.

The Commission of Research and education offers its thanks and deep appreciation to all of the agencies and individuals named and to all others who made contribution to the advancement of the Department's program. Such has encouraged the permanent staff as well as aided directly and materially in the effort to accomplish objectives both timely and essential to the cause of conservation.

R. V. TRUITT, *Director.*